Prince George Forest Region

Forest Resources & Practices Team

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FOREST RESEARCH NOTE

Connectivity

by Scott Harrison, Wildlife Habitat Ecologist

Introduction

This Research Note is an excerpt from ***Chapter 2: Connectivity*** in the book "***The Ecological Principles of Forest Management***" (Voller and Harrison in preparation). This larger work is a synthesis of the literature and provides information about the ecological principles and management strategies intended to conserve native fauna and their native habitat. In the book, the chapters are referenced; however, for considerations of space, the references have been omitted here. Please contact the Research Section, Prince George Forest Region for more information.

Many ecological processes are connected across taxonomic groups. Fairy parasols (right) grow on the nitrogen-rich microsites created by caribou pellets. These non-vascular plants "move" throughout the landscape by emitting an odour attractive to insects. When the insects land, they pick-up spores. The spores are then dispersed as the insects fly from pellet group to pellet group following the caribou.

Background

Connectivity is an ecological term that describes the natural habitat continuum throughout the landscape: the antithesis of fragmentation. Connectivity denotes linkages among habitats, species, communities, and ecological processes at many spatial and temporal scales. Connectivity allows for flows of water, energy, nutrients, disturbances, and organisms and their genes. The collective habitat requirements of species need to be viewed as interacting, functional components of the landscape ecosystem.

Early notions about connectivity arose from the theory of island biogeography. This theory states that the number of species on an oceanic island represents a balance between extinction and immigration rates. Distant islands would have lower immigration rates than near-shore islands because the near-shore islands could be colonized by species that could travel (fly, swim, water-drift, wind-drift) from the mainland. In essence, the near-shore islands were "connected" to the mainland.

In 1970, the idea of metapopulations was introduced as a model to describe the way populations exist and interrelate. A metapopulation is an interconnected group of populations where there is interchange of individuals (Figure 1). Some populations may experience local extirpations (where local population is wiped out), however, recolonization by connected populations prevents the overall extinction of the species. Fragmentation is thought to have the effect of converting continuous, stable metapopulations into increasingly unstable, disjointed populations.

This idea that populations are linked is built on the theory of island biogeography because unconnected habitats would not retain the complete inventory of fauna that would occur in a larger area. For example, protected areas can become "islands" as the surrounding habitat is developed. In a study of 14 western North American parks, 13 of the parks had lost 43% of their historic mammalian assemblages in 3 taxonomic orders (Lagomorphs, Carnivores, and Ungulates).

Corridors are a mechanism used to provide linkages among habitat patches and maintain connectivity in

managed landscapes. A corridor is a remnant of naturally occurring vegetation that allows movement of individuals or genes between patches of natural habitat. Corridors are not always linear and, in some landscapes, may not be necessary to maintain connectivity. Any combination of patches that are acceptable for a particular species to move through, or live in, can maintain connectivity. Traditionally, ecologists have studied different landscape elements as separate entities. Many scientists recognize the need for the new study of landscape ecology; the study of the landscape matrix as a whole.

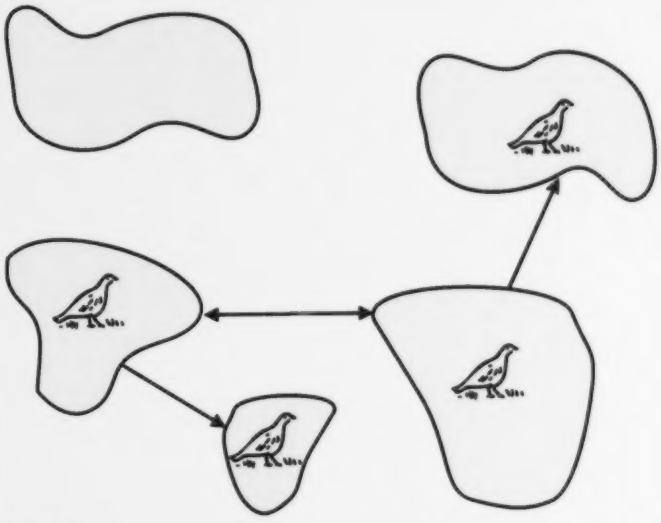

FIGURE 1
Schematic representation of a metapopulation
Shapes represent suitable habitat patches for individual "populations", and the collection of these populations forms the metapopulation. Connections between patches are indicated by directional arrows. Where these connections exist, individuals from one population can move to other habitat patches. The empty habitat patch represents an area where species have been lost, and recolonizaiton is not possible because of the loss of connectivity to that patch.

Managing for Connectivity

Management for connectivity in a landscape should maintain a continuity of habitats and processes. Connectivity of ecological processes are as important as connectivity of habitats. The intent is not to reconnect isolated habitats but to keep natural connectivity at many scales. This is done by maintaining links among ecosystem processes, interior habitats, and undisturbed habitats to help in dispersal and recolonization of disturbed areas.

Connectivity should be maintained at the landscape level. A landscape unit may be a mountainous watershed of 5,000 ha or an undulating plateau of 100,000 ha. In either case, the landscape unit is a distinct, measurable unit with a recognizable and repeated cluster of ecosystems and disturbance regimes. For each landscape unit, connectivity objectives should be set. Objectives should be specific and focused on issues such as the viability of specific target species; rare and threatened species should receive special consideration. Some authors state that connectivity objectives should address the stabilization of natural biological diversity not just a reduction in the rate of species loss.

Connectivity objectives need to account for all habitat disturbances within the landscape unit. The objectives should consider the duration and extent to which different disturbances will alienate habitats. Fencerows that maintain connectivity in an agricultural landscape would need to be maintained indefinitely if the surrounding land remained as agricultural. Conversely, linkages that maintain connectivity in a newly logged landscape could be replaced by other areas within the landscape as the new forest grows. However, ecologists note that, in the managed forests of the future, reserves may be "islands" in a sea of a short-rotation plantations, and that these plantations will not act as source pools to recolonize the reserves. Therefore, before corridors of old-growth habitat are replaced by younger stands, there should be evidence that the new forest will provide habitat attributes similar to the original linkage (*i.e.*, complex forests not simplified plantations). In all cases, the objectives should acknowledge that the mechanisms used to maintain connectivity will be required for decades or centuries.

Despite gaps in the understanding of the mechanisms to maintain connectivity within landscapes, it is better to retain corridors and then assess their role than to lose corridors and find out they were important. Bennet (1991) summarizes the situation as follows:

> *Despite our limited knowledge concerning the use of corridors by plants and animals, we must proceed with the designation and management of corridors on the basis that they are beneficial to nature conservation. Until further knowledge is available, management should endeavour to: retain existing corridors and corridor networks; maintain corridors as close to a 'natural' or 'pristine' state as is possible, in order to leave future management options open; and avoid activities or disturbance that will reduce corridor width or lead to an increase in 'edge' effects in the corridor.*

The conservation objectives of corridors should be established as part of the overall connectivity objectives for the landscape unit. Frequently, corridors are intended to facilitate the movement of organisms by extending interior forest habitat characteristics through areas of timber harvest. Although planning discussions can be eased by simply placing corridors in "inoperable" or "non-productive" areas where timber harvest is not feasible, maintaining connectivity among "productive" areas is essential.

There are few data indicating how corridor width and composition may influence faunal movement, although many authors feel that these are important considerations as to the effectiveness of a corridor network. In broad terms, for a faunal dispersal corridor to be effective, its size should be appropriate for the ecological function being asked of it; the width should be appropriate to the scale of the phenomenon being addressed. Bigger animals need wider corridors, and corridor networks in heavily disturbed ecosystems should provide more habitat for connectivity of ecological functions. Of course, all corridors, regardless of their width, should connect areas of useful, protected habitat.

Ultimately, the effectiveness of a corridor depends on the amount of human activity in and around the corridor, and the optimum corridor width depends on the strength of the edge effect. The following outlines the importance of corridors buffering against edge effects:

> *The corridor must provide protective cover for species from natural predators, domestic animals, and human effects lining each side of the corridor. The outer portions of the strip corridor have the edge effect, while the central portion contains the interior environment required for many patch interior species. For this reason, the width of a strip corridor is critical, since the interior environment must be present and sufficiently wide itself to be used by interior species (Forman and Godron 1981).*

There is a range of edge effects that occur along the interface of interior and disturbed habitat types: 1) biological edge effects (predation, herbivory, and weed invasion); 2) physical effects (light, temperature, humidity, nutrient status, hydrology changes, wind effects); 3) human effects (pollution, domestic animals, hunting).

The greater the difference between the corridor and the surrounding habitat matrix, the deeper the edge effect goes. "Feathering" edges around reserves and corridors (i.e., partial-cut logging instead of clear-cutting with "hard" edges) is one method of mitigating against some edge effects. Other authors feel the solution is more straightforward — to minimize the edge effect — widen the corridor.

Optimum widths are impossible to specify and should be assessed in relation to the life histories and requirements of the fauna for which the corridors are intended. In Maine, species known to do well in edge habitats - moose, white-tailed deer, and black bear - used corridors 76 to 152 metres wide. Others found that habitat use by mule deer was up to 3.3 times greater 300 to 400 metres from roads. Some authors found that 30 metre wide tracts had processes characteristic of edge forests, and it was necessary to move 250 metres beyond the edge before interior forest characteristics were found. Clearly, corridors need to be greater than twice these widths to ensure interior forest process can occur. One author uses these measures of edge effects to present minimum, useful corridor widths of 1.2 to 6.4 kilometres to provide interior habitat within the corridor.

Corridors should be large enough to absorb natural disturbances and should have multiple connections to cover many scales of disturbance. Corridors also should remain functional until the surrounding habitat matrix can return to a natural state following a disturbance. One should accept the working hypothesis that wide, continuous corridors are most likely to foster movements. Harris and Scherk (1991) summarize these criteria as follows:

The size of a corridor should reflect the size and dispersal characteristics of the organism for which the corridor is intended. Species such as cougars and amphibians will perceive these connections differently.

> *When the movement of individual animals is being considered, when much is known about their behaviour, and when the corridor is expected to function in terms of weeks or months then the appropriate corridor width can be measured in metres (c. 1-10 m).*
>
> *When the movement of a species is being considered, when much is known about its biology, and when the corridor is to function in terms of years then the corridor width should be in 100s of metres (c. 100-1000 m)*
>
> *When the movement of entire assemblages of species is being considered and/or when little is known of the biology of the species and/or if the faunal dispersal corridor is to function over decades, the appropriate width must be measured in kilometres.*

Ministry of Forests, 5th Floor, 1011 - 4th Avenue, Prince George, BC V2L 3H9 Telephone: (604) 565-6100 Fax: (604) 565-4349

Current Research in the Prince George Forest Region

In British Columbia, the issue of connectivity has been prominent throughout the development and implementation of the Forest Practice Code. As with many issues that involve large spatial scales, there are few empirical data anywhere in North America on the role of connectivity or how to maintain connectivity in a managed landscape. One reason for this lack of data is the difficulty in conducting an ecologically meaningful and statistically rigorous experiment at the scale of a landscape. However, the fact remains that these data are required to make informed decisions about sustainable forest management.

The Wildlife Habitat Research program in the Prince George Forest Region is initiating a study that will provide empirical information about landscape connectivity. The project ***Connectivity and Ecological Complexity in Riparian Landscapes*** is being conducted in conjunction with industry, Ministry of Environment, Lands and Parks, U.B.C., U.N.B.C., and the Sustainable Forest Management Network of Centres of Excellence Program.

This study is investigating ecological functions in the forest by examining the relationship between the level of natural disturbance or forest management activity in a riparian landscape and changes in the rates of animal population dynamics. The objective is to determine how the rates of ecological processes (movement, predation) are related to the extent of connectivity in a riparian landscape. This relationship is important because managers need to know what rate of change is sustainable within a landscape. For example, there may be a threshold value beyond which processes breakdown, and the system changes irrevocably (*i.e.* species go extinct).

Two processes related to wildlife populations have been chosen for study: movement and predation rates. These processes were selected to enable the data to be interpreted and applied in other areas of the Province. Animal movement was chosen because of its role in linking populations through dispersal, and because of its association with the management issues of corridors, fragmentation, and riparian buffers. Predation rate was chosen because it links groups of wildlife through the predator-prey interaction, and because of the its importance in the maintenance of wildlife systems.

Spruce grouse, snowshoe hare, and beetles were chosen for a combination of reasons:

- ability to acquire suitable sample sizes through live capture;
- high population turn-over rates to increase probability of measuring a response to treatment;
- animals with ranges that are feasible to track;
- a range in the scale of movement patterns for comparative analyses between species;
- prey species enable inferences about the effectiveness of predators, and;
- a mix of species' dependence on forested habitat to broaden the project's applicability and to compare species' response to treatment.

Riparian ecosystems are thought to be important for linking ecological process in the landscape.

This study will provide empirical data that are directly linked to the Forest Practices Code and the Provincial Biodiversity and Riparian Strategies and will aid in the development of forest management decision-support tools for riparian and landscape-level management. Information collected will provide extension support for integrated resource management initiatives.

Literature Cited

Bennett, A. 1991. What types of organisms will use corridors. Pp 407-408 in D.A. Saunders and R.J. Hobbs (Eds.), Nature Conservancy 2: The Role of Corridors, Surrey Beatty and Sons, NSW, Australia. 443pp.

Forman, R.T.T., and M. Godron. 1981. Patches and Structural Components for a Landscape Ecology. BioScience 31: 733-739.

Harris, L.D. and J. Scheck. 1991. From implications to applications: the dispersal corridor principle applied to the conservation of biological diversity. Pp 189-220 in D.A. Saunders and R.J. Hobbs (Eds.), Nature Conservancy 2: The Role of Corridors, Surrey Beatty and Sons, NSW, Australia. 443pp.

For further information

Scott Harrison, Wildlife Habitat Ecologist
BC Ministry of Forests, Research Section
5th Floor, 1011 - 4th Avenue, Prince George, BC V2L 3H8
Telephone: (604) 565-6100 Fax: (604) 565-4349
e-mail: swharris@mfor01.for.gov.bc.ca